Perceptions of climate change and local responses on livelihoods: the case of people around the Mambioko community forest

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Abstract

Forest provides services, directly linked to micro and macro environment, water and soil resources, plants and animals' diversity, food production and security and energy resources. This study contributes to other studies and growing literature on climate change impacts and adaptation strategies in the Congo Basin forest, particularly Cameroon's forest region. Mambioko has a four-season climate, with annual precipitation of 2000–3000 mm and temperature variations of 21.8–30.8 ◦C, most of its agriculture is rainfed. It has an evergreen or semi-deciduous rainforest corresponds to the ""humid"" and "low- and medium-altitude sub-humid" eco-floristic zones. This study is carried out to identify and assess climate change impacts on the livelihoods of forest-dependent communities in Mambioko community forest in Cameroon. Primary data were collected from 85 households; key informants, and focus group discussions and were supplemented with secondary data from a desk review of relevant literature. The study shows that climate change impacts the major livelihood activities of forest-dependent communities through prolonged drought, erratic rainfall patterns, and variability in rainfall intensity. Four of the critical activities of local communities impacted by climate change are agriculture, hunting, fishing and collecting non-timber forest products. People respond to the negative impacts by adopting simple irrigation systems, crop diversification, alternative livelihood activities, and increasing their farm sizes. This study concludes that future interventions to help forest-dependent communities cope with climate change impacts will require pursuing alternative non-climate-dependent livelihood activities, increasing access to climate information, and adopting sustainable agricultural and forest management practices.

Keywords: Forest communities; Climate change; Vulnerability; Adaptation

Introduction

The past climate changes are responsible for the recently impacts on natural and human systems globally. There is strong evidence of climate change impacts. The evidence is very comprehensive within the natural systems. Various impacts is linked to the climate change and their minor or major contributions are distinguishable from other influences with the human systems (Niang et al, 2014). As climate change gives rise to more frequent and devastating severe storms, droughts, and wildfires, an increasing number of communities worldwide are facing existential threat due to continued damage to already vulnerable water and electricity infrastructure (Godart & Hart, 2020). Thus, scholars believe that the climate change vulnerability directly affects the livelihoods of ' 'farmer's whose activities are highly dependent on natural resources, leading to accelerated rural–urban migration (Barrios et al., 2006). Insecurity related to agricultural production within a climate change scenario is likely to make rural households to respond in ways that are not yet well understood. In the context of interactions between humans and the natural environment, migration has been identified as a potential adaptation response to adverse climate effects (Nawrotzki et al., 2015; Viswanathan & Kumar, 2015; Bohra-Mishra et al. 2017; Nawrotzki & Bakhtsiyarava 2017; Falke et al. 2006). Compelling evidence has suggested that because shifts in average and variability of temperature and rainfall levels lead to a decline in agricultural income, employment opportunities, or food security, the climate–migration nexus is mostly intermediated by the agricultural channel (Cattaneo & Peri 2016; Falke et al. 2006). Even extreme restraint of greenhouse gas emissions can only slow the pace of temperature increases, given that past emissions remain in the atmosphere (IPCC 2018). The 0.7 °C rise in global temperatures over the past 30 years (or 1 °C over the past 50 years) is significantly higher than in any equivalent period during the last 10,000 years (Marcott et al., 2013). Sub-Saharan Africa is the region in the world most vulnerable to climate change. Rising temperatures, rising sea levels, and rainfall anomalies are increasing the frequency and intensity of natural disasters and are markedly transforming the ' 'region's geography (IPCC, 2018).

Over the last two decades climate change adaptation has emerged as a central and now acknowledged component of the international climate change policy and research agenda (Klein et al., 2014; Owen, 2020; Swart et al., 2014). The Paris Agreement and its Article 7 have secured a prominent platform for climate adaptation as a key issue for global governance (Persson, 2019). Adaptation received its own ISO standard [ISO 14090] in 2019, cementing it further as a distinct area of research, policy and practice. Specific climate change adaptation conferences, such as the Adaptation Futures series, have been running since 2010 and new scientific degrees and professional certifications are being developed specifically for climate adaptation. That climate change adaptation literature is flourishing is evidenced also by the rapid expansion of the number of publications with a focus on climate change adaptation (Di Matteo et al. 2018; Giupponi & Biscaro, 2015; Hauschild., 2016; Preston et al., 2011, 2013) Adapting to a changing climate and managing climate risks are increasing worldwide concerns (Moss et al., 2013; IPCC, 2014). Evidence of climatic changes and increasing frequency and intensity of extreme weather events is mounting, as recognized in the Assessment Reports (AR) of the Intergovernmental Panel on Climate Change (IPCC). It is also clear that climate change will accelerate under current and projected greenhouse gas emissions (Bauer et al., 2012; Adger 2006; CCC, 2017). As the importance of adaptation has been emphasized through international agreements (Lesnikowski et al., 2017), the functions and roles of national level adaptation actions also have been emphasized (Storbjork ¨ and Hedr'en, 2011; Mullan et al., 2013; Eisenack et al., 2005; Waters et al., 2014; Berrang-Ford et al., 2014). Also, several national adaptation policies and plans have being developed since 2007 (IPCC, 2014). Despite the

substantial progress of national adaptation policy, issues related to the effectiveness of national adaptation policies have been raised, and ' “adaptation”gaps’ are constantly reported (UNEP, 2018).Adapting to climate change is critical to safeguarding and further advancing hard-earned improvements in incomes, education, and health across sub-Saharan Africa over the past three decades. However, adaptation will be especially challenging given”countries’ limited capacity and financial resources. Several studies have clearly shown the importance of advancing economic development in raising resilience to climate change and improving coping mechanisms (Hallegatte et al., 2016, 2017).Climate change-induced natural hazards increase both in magnitude and frequency, thereby threatening the stability and sustainability of social-ecological systems. Society must adapt its economic, institutional, political and social practices to protect the physical environment on which it depends from anthropogenic climate change (IPCC, 2012). Global responses to man-made climate change focus on adaptation and mitigation efforts. Planned adaptation efforts are geared towards minimizing the risk of an already occurring climate change, while taking advantage of associated opportunities (World Bank, 2012). However, the uptake of decision support tools by non-scientific stakeholders (local communities) is challenging due to many factors (including prohibitive financial cost, top-down design of the tools, poorly designed participation processes and technical complexity). These explains local communities' low uptake of decision support tools, especially in developing countries (McIntosh et al., 2011; Abbas et al., 2016). The agricultural sector is sensitive to climatic conditions, and it has become one of the most susceptible sectors affected by the menaces and effects of global climate change. Notwithstanding its huge contribution to the economy, it has been facing constant and earnest challenges of many factors. Instances of climate-related disasters like floods and drought, are notably the major ones, climate variability adversely affects agricultural sector and the situation is exacerbate in the future (Organization for economic co-operation and development (OECD, 2015). Cameroon is threatened by climate change and climate variation. Government support for the small-scale farming sector is grossly inadequate (Mugiya and Hofisi, 2017). The consequence is seen in the increasing numbers of Cameroonians (about 3.9 million, or 16 percent) facing moderate to severe food insecurity (WFP, 2017). In the forest zone of Cameroon, recent studies indicated that climate change is already harming the livelihood strategies of rural people (Bele et al., 2013). Drought, changing seasons, erratic rainfall patterns, heavy rainfall, and strong winds are among the main climate-related disturbances perceived by local people. It has being realized that at the local level coping strategies have been developed. Still, there is a limit to broader community resilience that is being fostered at the individual level (Bele et al., 2013). While small-scale farmers living in areas of high environmental stress in the developing world may be highly capable of adapting to short and long-term climatic and environmental variations (Challinor et al., 2007). It is important to understand and know the impact of climate change on the livelihoods of the forest-dependent communities and the respond of these communities within the context of their adaptation strategies which in future will reduce their vulnerability and enhance their livelihoods activities. In Cameroon, climatic variability (with the dry season becoming drier and the rainy season becoming wetter) is observe from country’s climate data (Molua and Lambi, 2006, 2007). An increase in the rainy season may also give rise to other impacts, such as pre-harvest and post-harvest damage of food and cash crops, due to limited resources for preservation and lack of preparedness. Such damages can be seen within the context of income shocks likely having a larger impact on the poor (Kurukulasuriya, 2006).

Conceptualizing vulnerability based on IPCC-AR5 framework

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change, i.e., IPCC-AR5 (IPCC, 2014) defines the risk of climate change at the intersection of’ ‘Hazard',’

‘Exposure' and’ ‘Vulnerability'. In this modified risk-assessment framework,’ ‘vulnerability' is conceptualized as an ‘internal property of a system’. It represents the propensity or predisposition of the system to be adversely affected, independent of hazard and exposure. While mitigating climate hazards and reducing exposure are relatively long-term goals, governments and development agencies may address climate change adaptation most effectively by reducing vulnerability in the short and medium term.

Sensitivity: Sensitivity refers to the degree to which a system or species is adversely or beneficially affected by climate variability or change’ (IPCC, 2014). It determines the first-order impact of a hazard or stressor on the system. The effect may be direct (e.g., change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

Adaptive capacity: Adaptive capacity is being defined as “the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to”consequences’ (IPCC, 2014). For example, if a comprehensive crop insurance system is in place, farmers can cope with crop damage caused by hazards such as floods or drought. The IPCC AR5 (IPCC, 2014) also states: The first towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability.

Aligning livelihood strategies and natural resource management along new trajectories of climate risks and livelihood adaptation is essential in national policies and programs geared toward reducing the vulnerability of forest-dependent communities (Sonwa et al., 2011a). Private businesses such as logging and mining companies operating in and around communities are relevant in facilitating and building community capacity. Lastly, civil society organizations such as community-based membership organizations and cooperatives offer great facilitation and capacity building opportunities in local communities (Agrawal, 2008).This study contributes to other studies and growing literature on climate change impacts and adaptation strategies in the Congo Basin, particularly Cameroon's forest region.

This present study is to attain the following objectives: to identify major climate-sensitive livelihood activities at the household level: local community dependency on major climate-sensitive livelihood activities; to examine the local perceptions on climate change impacts on major livelihood activities and socio-economic vulnerability, and the available coping and adaptation strategies.

Descriptions of the study area

Cameroon is bordered by Central African Republic 797 km, Chad 1,094 km, Republic of the Congo 523 km, Equatorial Guinea 189 km, Gabon 298 km, Nigeria 1,690 km. Community forests management in Cameroon emerged after the 1994 Forestry law. The law gave rights to communities to manage a forest area not exceeding 5000 hectares, after a management agreement between village community and state forests administration, for a period of 25 years renewable after every 5 years (GoC, 1995).The site selected for this study (Mambioko) is about 40 km away from the chief town of the Ngambe-Tikar subdivision.

The study site is chosen based on the accessibility, number of villages, and dependency of the community on climate-sensitive livelihood activities. The study site is covered by a community forest name "Chily Revolution Verte du Cameroun" (CRVC) (Fig. 1). CRVC community forest was created in 2009 with a total surface area of 4998 ha, and its fall in bi-modal moist forest

agro-ecological region with an annual rainfall range of 1500–3000 mm;mean temperature of about 23 °C (Bele et al., 2013), and a population of about 800 inhabitants with a population density of about 7 people per km^2. They are in the transition zone between Northwestern Congolian lowland forests and Northern Congolian forest-savanna mosaic. The local economy is being based on the exploitation of natural resources including timber agriculture, hunting, fishing, and non-timber forest products (NTFPs).

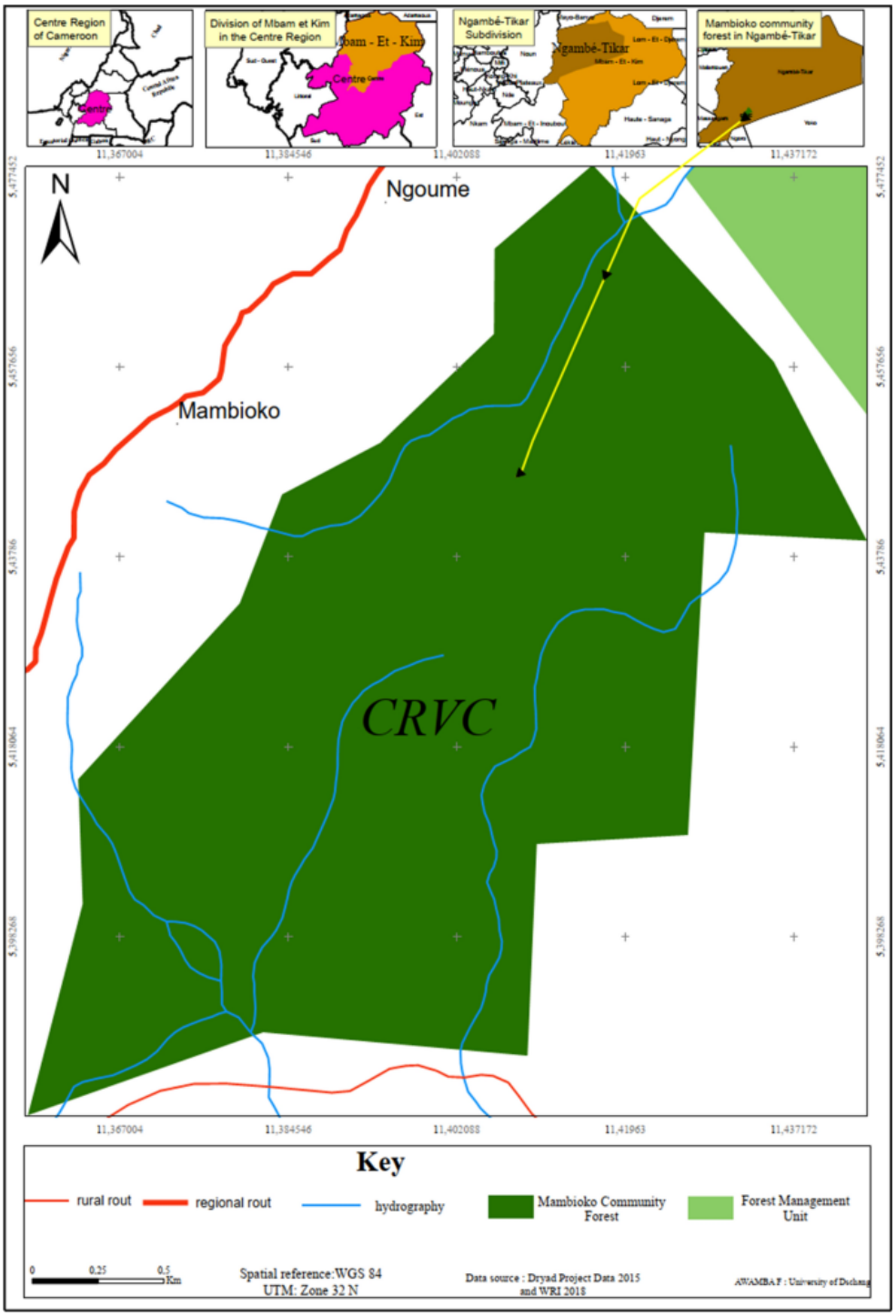

Fig. 1. Layout map of the study site

Socio-economic and livelihood attributes: Mambioko village is made up of. about 800 inhabitants the majority of the population is tikar. The other ethnic groups present are in order of importance the Yamba, the Mambila and the Mbororos. In addition to subsistence and commercial farming for income, village women are involved in household chores or they are responsible for managing the household. They are also involved in associative movements, “tontines” that serve as savings. The main activity is agriculture in Mambioko village.

All households practice subsistence agriculture (men, women and youth); these crops are cultivated mainly in individual fields. The main crops are (maize, cassava, plantain, and cocoyam) which are intended for consumption and sale. The main cash crop is cocoa. In addition to agriculture, there is also the involvement of women and some men in the collection of non-timber forest products such as njansang. Most of the collection of non-timber forest products (njansang) is done by women, but there are also some men and children who collect it. Globally, about 50 ha of land is used for mixed cropping (cocoa and plantain)

Temperatures and rainfall extension

It has a four-season climate, with annual precipitation of 2000–3000 mm and temperature variations of 21.8–30.8 °C, most of its agriculture is rainfed. It have an evergreen or semi-deciduous rainforest corresponds to the ""humid"" and "low- and medium-altitude sub-humid" eco-floristic zones (Lambi & Neba, 2010; UNEP, 2008). Until recently, the abundance of land in this region enabled its residents to sustain agriculture by shifting cultivation and using slash-and- burn methods.

Table 1. Changes in annual rainfall (mm) and mean temperature (◦C) distribution for Ngambe-Tikar (2001 to 2010)

Year	Annual rainfall		Annual temperatures	
	Rainfall	Changes	Temp	Changes
2001	2260	−158.9	28.3	−0.3
2002	168.1	−177.8	28	0.5
2003	1503.3	207.1	28.5	0.1
2004	1710.5	269.2	28.6	−0.3
2005	1979.6	91.4	28.6	0.3
2006	271	−546.5	28.6	0
2007	1524.5	110.5	28.6	−0.1
2008	1635	460.7	28.6	0.6
2009	2095.7	792.1	29.1	0.1
2010	2887.8	792.1	29	0

Variation in temperature and rainfall

This study focused on several climatic variables that particularly affect climate sensitive livelihood activities in the three villages: rainfall and temperature (heat and intensity). Climate change and climate variation, as seen in changing rainfall patterns, has become a ""new normal"" for most small-scale farmers (Table 1). The realization of this variation has led to no significant change in farming practices in these communities as many farmers continue to

depend on the traditional rainfall calendar. With two major seasons (rainy season from March to October and dry season from November to March) in Cameroon, most farmers have limited access to the weather forecast and begin sowing after the first rains in March. With a significant alteration of the traditional farming calendar, these crops dry up, are destroyed by insects, or the seeds are baked by sun heat and never geminate. Climate- sensitive livelihood activities is regarded by many participants as a very risky profession as they lack access to financial and technological resources, such as irrigation, to manage climate stressors.

Methodology

Data collection

Sample frame

A sample size of 20% of the population was selected following Mugenda and Mugenda (2003), states that a sample of 10.0–20% of the total population for a large or small population is sufficient to get information concerning the population under study (Table 2). In each selected strata, all households head or representatives aswas interviewed. A total of 85 (both men and women) were selected randomly during the survey (Ngoume 25, Mambioko 30, Mbidi 30 of the households) Table 3.

Table 2. Annual precipitation (mm) and mean temperature (◦C) distribution in Ngambe-Tikar Sub-division (2001–2010)

Year	Annual Rainfall	Ngambe-Tika Sub-division Annual Temperatures
2001	2360	28.3
2002	1681.1	28
2003	1503.3	28.5
2004	1710.4	28.6
2005	1979.6	28.3
2006	2071	28.6
2007	1524.5	28.6
2008	1635	28.5
2009	2095.7	29.1
2010	2887.8	29

Table 3, Sample populations

Strata	Population (HH)	Proportion (%)	Sample size
Ngoume	250	10	25
Mambioko	300	10	30
Mbidi	300	10	30
Total	850	30	85

Primary data

Data were collected from Mambioko community forest areas respectively using a combination of different methods. Focus group discussions were used during data collection with one focus group for each village. Groups comprised of men and women the age chosen for the respondents was 27 years and above, capable of providing data and information on observations on climate change and livelihoods relationships for the past 10 years. Brainstorming was the dominant tool used during the focus group discussions, including historical trend observations.

The focus group discussion was complemented by household surveys using semi-structured questionnaires. Simple stratified random sampling was used to identify households. We made sure that respondents had a permanent stay in the area for at least 8–10 years. In Ngoume, one after every two households was sampled from the start of the village to the end, as the village is located along a 2 km road stretch. Questionnaires were administered to households independently, with each interview lasting between 45- 54 min.

A discussion guide was developed for the key informants comprised of the local leaders (chief of Mambioko, Mbidi, and Ngoume villages); the delegate and secretary general of the community forest. Besides we also had the headmaster of Mambioko primary school, the chairpersons of the local farming groups, the lead persons for the local women groups, and leading farmers in the villages. Furthermore, to gain an overall perception of the 'residents' views on climate change and its impact in each village field observation was employed focusing on farm sizes, distance of farms from households, farming methods, and type of crops.

A pilot study was conducted before the main study to test the tool's validity and reliability. It helped to establish the consistency of the questionnaire in terms of the time and location, and to identify areas in the questionnaires that need clarity for the easy understanding and respond appropriately.

Secondary data

Literature review formed part of the secondary data, gave the theoretical base for the research, and helped determine the nature of this study. It helped to identify what is already known about this study's area. Mobile technologies were used to collect the data in the form of structured questionnaires for all the sampled groups.

Data analysis

The raw data were examined and organized into manageable units for analysis to establish the accuracy of the research study. Obtained data was analyzed using Excel 2010 (to generate percentages on major livelihood activities and perception of climate change impact) and statistical package for social scientists (SPSS). The data was displayed in the form of frequency 'tables' proportions (percentages) and the use of measures of central tendencies, ANOVA 19, to clearly understand the findings.

Results and discussion

Major climate-sensitive livelihood activities

According to some households during the survey, fishing and hunting were identified as significant climate-sensitive livelihood activities by 1. % and of the respondents respectively and ranked as the lowest climate-sensitive livelihood activities. Other livelihood activities were (non-dependent on climate-sensitive activities like business and white-collar jobs). The first major climate-sensitive livelihood activity was agriculture practiced by 59.8% households seconded by the collection of NTFPs with 36.7% of the respondents taking part (Fig. 2).

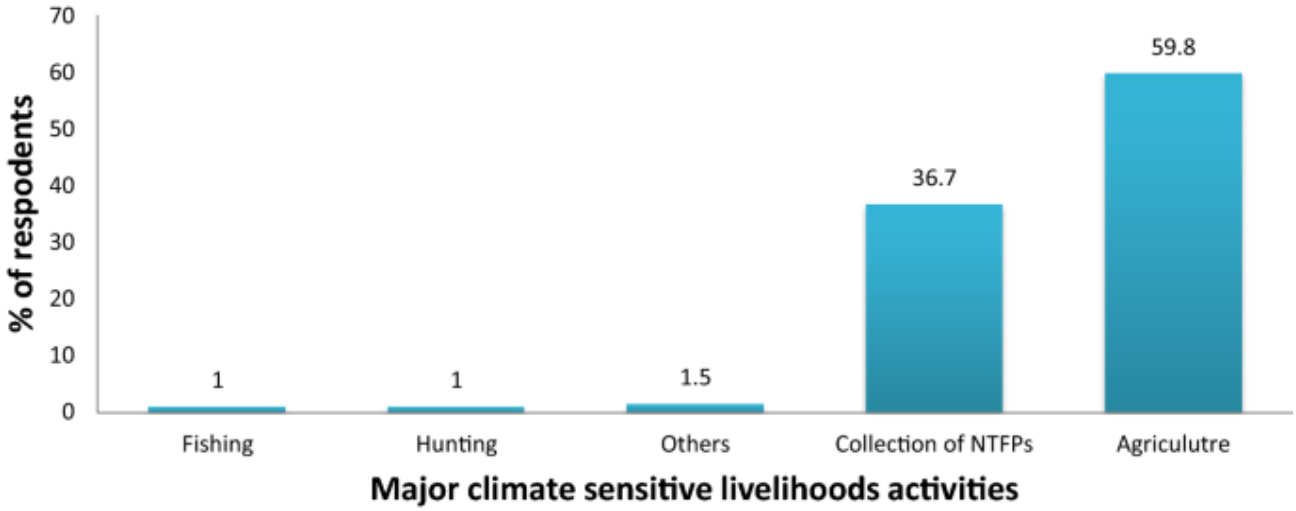

Fig. 2. Major climate-sensitive livelihoods activities

Level of dependency on climate-sensitive livelihoods activities

In the study area, respondents ranked their level of dependency on climate-sensitive livelihood activities based on the significant contribution those activities (tree products, plant materials, and forest products for food and agricultural activities like farming) make to 'household's income and other household needs (Fig. 3). The three-level ranking is used based on the following indicators: access to market, availability of assets, labor, skills, social capital, and natural capital. (High dependency = Home consumption and frequent sale of surplus on the local market; Moderate Dependency = Home consumption and occasional sale on the local market; Less dependency = Home consumption only). Generally, (46.7%) of the total respondents was ranked as having a high dependency on climate sensitive activities. In this category, respondents described the contribution of climate-sensitive livelihood activities to household income as very significant. The study showed that the level of dependency on fishing was 11.8%. O, which was ranked the third lowest dependency followed by hunting (6.8%), ranked second lowest dependency, and other activities (3.4%) ranked the lowest. The collection of NTFPs recorded second highest-dependency (39.8%) behind agriculture with the highest level of dependency at 99.2% (Fig. 3).

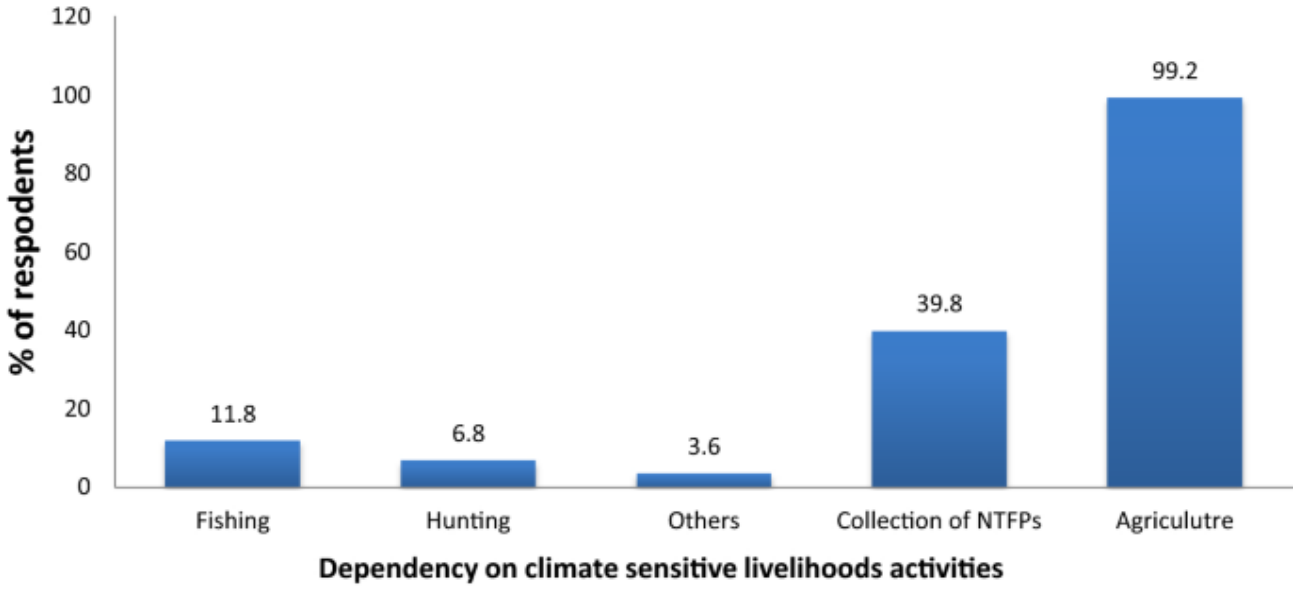

Fig. 3. Level of dependency on sensitive livelihood activities

Perception of climate change impacts on agricultural activities

Agriculture is still greatly dependent on climate; temperature, light, and water are the key drivers of crop growth. The perception of climate change's impact on agriculture is based on the following indicators: pest and diseases, drought, erratic rainfall, prolonged rainfall, low production, changing seasons, and strong winds. This study (74.6%) of the respondents agreed that pest and diseases are affecting agricultural activities for the past 10 years especially cocoa. Low production (83.2%) of the respondents agreed that this has been the principal climatic threat to their agricultural activities leading to food insecurity in these communities. Most respondents (81.5%) believed the erratic rainfall is one of the indicators of climatic stress that they are facing in their agricultural activities, which has changed their traditional farming system compared to the past. This finding is like another study by Bele et al. (2013). According to the survey 54.2% of respondents agreed that prolong rainy seasons were affecting their agricultural activities, resulting in severe post-harvest problems and food insecurity as earlier observed by Yengoh et al. (2010). In addition, 97.5% of respondents consider strong winds as one of the climatic stresses affecting their main livelihood activity (agriculture). It was reported that heavy rainfall is at times accompanied by a strong wind that pushes down crops like maize and off roots cash crops like cocoa, as reported by Bele et al. (2013). Following the household survey, most of the respondents (94.1%) agreed that increased climatic events like drought and high temperature have exacerbated the risk of bushfires that destroy crops in these villages. Most farmers in Ngoume and Mambioko are exposed to human-induced climate hazards like bushfires, which is mostly caused by traditional farming practices such as the ""slash-and-burn"" method used by farmers to increase productivity and by grazers to enhance the growth of the best grass for grass fed-animals. The effects of the fire are devastating as it sometimes leaves farmers with little or no harvest according to these communities. All the respondents (100%) in these communities agree that changing seasons affects their previously well-defined production calendar. Farmers need to adapt to unpredictable rainfall and dry season patterns (Fig. 4).

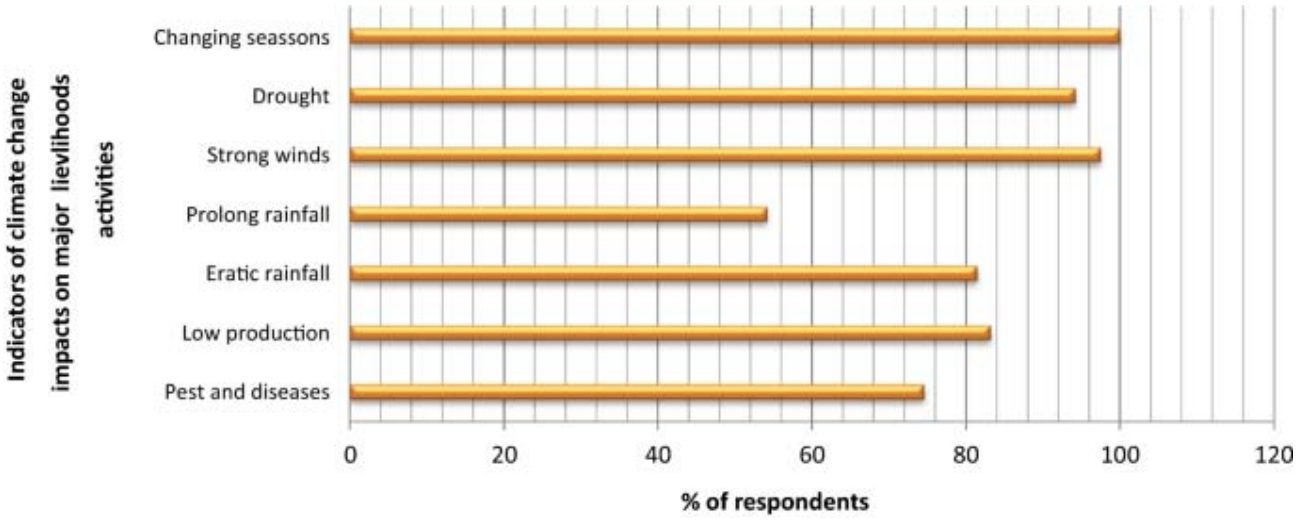

Fig. 4. Perception of climate change impacts on agriculture

'Respondent's perception of climate change impact on fishing

Fishing is another activity and a source of income for some households in the study area. A little over one third of the households (38.4%) agreed that the drying of watercourses because of unreliable rainfall has negatively impacted fishing grounds in these communities leading to a reduction in the quantities of fish caught over the last 35 years for commercial and subsistence purposes. In addition, most households (45.5%) agreed that drought was the principal climatic threat to fishing activity, especially during the short rainy seasons (Table 3). Furthermore, fewer household (16.2%) agreed that heavy rainfall affects fishing in these communities especially as the rainy seasons have become heavier in recent years.

Perceptions of respondents on the impacts of climate change on NTFPs

Forest resources in the form of NTFPs serve as safety nets, sustaining the livelihoods of some forest communities in Mambioko. They play a vital role in income generation and household food security (Lambi & Neba, 2010). The results of this study indicate that the collection and sale of NTFPs is a major livelihood activity and a source of income for households especially in Ngoume. Access to NTFPs is open to the peoples in community forest settings as they collect NTFPs such as Bush mango (Irvingia gabonensis), Njansang (Ricinodendron heudelotii) and fuelwood. NTFPs constitute about 40% of households' main livelihood activity and source of income. Still, about 92% of the households stated that heavy rainfall prevents their collection. Households in Mbidi are involved in collecting NTFP as their main livelihood activity. Still, the harvesting of fruits from different tree species is at times poor because of poor flowering and fruiting of the tree species. In addition, 94% of the households stated that drought has caused a serious problem in the collection of some NTFP species especially njansang which has become very difficult for the pulp to decompose and allow for cracking to remove the nuts. From drought, over 98.1% of the households indicated that changing seasons is currently affecting the collections of NTFP. This refers to unpredictable seasonality with dry months becoming drier, prolonged dry season and erratic rainfall that all affect the resilience of some NTFP-producing plant species. Based on local knowledge by about 85% of households in

Ngoume, other factors such as pests and diseases affect the flowering and fruiting NTFP tree species and the collection and harvesting of their fruits (Fig. 5).

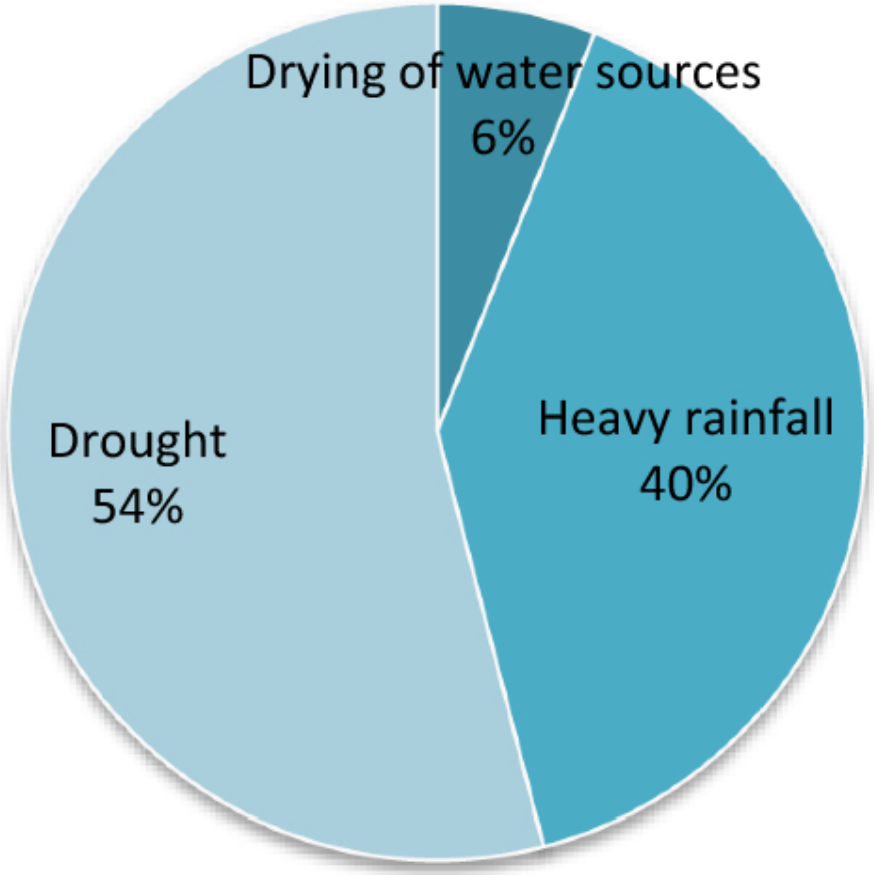

Fig. 5. Impact of climate change on the collection of NTPs

Perception of future variation in temperature

Agriculture is the most vulnerable sector to climate change, owing to its huge size and sensitivity to weather parameters, thereby causing huge economic impacts (Mendelsohn, 2000). According to 40% of the respondents, there will be a continuous increase in temperature in the years to come because, for the past ten years, they have witnessed persistent heat in their communities due to high temperatures. Conversely, 60% of respondents from Mbidi village stated that temperature will fall or decrease in the years to come with potentially devastating consequences on cash crops (Tables 4, 5).

Table 4. Frequencies of perception of climate change impact on fishing

		Responses		Percent of Cases
		N	Percent	
Indicators	Drying of water sources	38	38.4	58.5
	Drought	45	45.5	69.2
	Heavy rainfall	16	16.2	24.6
Total		99	100.0	152.3

Table 5. Frequencies of respondents on future variation in temperature

		Responses		Percent of Cases
		N	Percent	
Temperatures	Increase	24	40.0	51.1
	Decrease	36	60.0	76.6
Total		60	100.0	127.7

Perception of respondents on the future variation in Rainfall

The majority of respondents (87.5%) predicted that there will be a continuous increase in rainfall in the coming years because some watercourses disappeared some years back have started regaining their positions. A majority of others (12.5%) believed that rainfall will decrease in the nearest future due to increased temperatures (Table 6).

Table 6. Frequencies of Respondents on the future variation in Rainfall

		Responses		Percent of Cases
		N	Percent	
Rainfall	Increase	7	87.5	87.5
	Decrease	1	12.5	12.5
Total		8	100.0	100.0

Socioeconomic vulnerability of respondents in the study site base on five selected indicators

There is no accepted set of variables for vulnerability to climate change, but age, gender, race, and socio-economic status are generally accepted and used (Cutter et al., 2008). The socio-economic vulnerability in the study site was estimated using five indicators. In the estimation, the following assumptions was made:

- 5.1.1: Level (LE): Lower education level is associated with higher vulnerability

- 5.1.2: Level of Awareness of Climate change issues (Access to Climate Change information (ACI): Lower access to climate change information is associated with high vulnerability
- 5.1.3 Dependence on climate-sensitive activities (DCA): Higher dependence on climate-sensitive occupation is associated with higher vulnerability
- 5.1.4 Low income (High income is associated with lower vulnerability and lower income is associated with high vulnerability
- 5.6.5: Poverty is associated with high vulnerability.

ANOVA was used to compare the total sum of squares between and within groups of respondents on the socioeconomic indicators of climate change vulnerability. Based on the five selected indicators, access to climate change information having a sum of squares (50.753) of respondents believed that their socio-economic vulnerability are caused by their limited access to information on climate change issues. High dependency on climate-sensitive livelihood activities like cash crops with a total sum of squares of (113.224) attests to their socioeconomic vulnerability. Besides poverty as reported by some respondents in Ngoume village as being responsible for their vulnerability to climate change impacts. Limited sources of income, low farm outputs, and low income levels all have a positive sum of squares suggesting their negative impacts that render households incapable of adapting to changing climatic conditions. Finally, Lower education level was among the most crucial socio-economic factors identified by respondents with a sum square of (19.412) as most households have never attended formal education (Table 7).

Local management, coping, and adaptation strategies are employed to cope with climate's impacts.

The framework for gaining access to both knowledge and the resources is translated into concrete actions to promote adaptation, must be provided by governmental and non-governmental institutions at the local, national and international levels (Yengoh et al., 2009). At the centre of communication and collaboration, (Vignola et al., 2009) advocate an ecosystem-based framework which addresses the problems of the ecosystem degradation and the conservation of natural capital is the main focus. In this study, households used fertilizers in their farms to increase yields with a std of (0.46832). The local agriculture system depends on natural temperature, sunshine, and rainfall. It implies the need for adjusting and improving (technically, financially, and materially) agriculture activities that will reduce vulnerability and increase the adaptive capacity of households. When bringing adaptation measures to the backyards, most households have planted trees around their houses to protect against strong winds during torrential rainfall with a std (0.50014). Such trees also provide microclimate to crops on farms.

Additionally, during the prolonged dry seasons and drought, households have adopted an irrigation farming system with a std (0. 40,237). They moved to swamps and opened new farms where water is available throughout the year and they use watering cans to send water into their farms. It is especially applied by a few privileged farmers that can afford the system which they commonly describe as a "climatic push factor".

Table 7. ANOVA for socioeconomic indicators to climate change vulnerability

Indicators		Sum of squares	*df*	Mean square	*F*	Sig.
Access to climate information	Between groups	40.940	2	20.470	171.045	.000
	Within groups	9.813	82	.120		
	Total	50.753	84			
Dependency on climate-sensitive livelihood activities	Between groups	3.124	2	1.562	1.163	.318
	Within groups	110.100	82	1.343		
	Total	113.224	84			
Poverty	Between groups	8.112	2	4.056	6.287	.003
	Within groups	52.900	82	.645		
	Total	61.012	84			
Level of income	Between groups	37.114	2	18.557	3.739	.028
	Within groups	406.933	82	4.963		
	Total	444.047	84			
Level of education	Between groups	12.134	2	6.067	25.495	.000
	Within groups	19.513	82	.238		
	Total	31.647	84			

Table 8. Coping and adaptation strategies

Indicators	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Increase use of fertilizers	85	.00	1.00	.3176	.46832	.219
Planting of trees to winds	85	.00	1.00	.5529	.50014	.250
Irrigation	85	.00	1.00	.2000	.40237	.162
Diversification of crops	85	.00	10.00	.8941	1.08038	1.167
Diversification of occupation	85	.00	1.00	.6706	.47279	.224
Increase in the cultivation of farm sizes	85	.00	1.00	.9529	.21302	.045
Valid *N* (listwise)	85					

Furthermore, following other studies (IDRC, 2009), households have diversified their crops, and sustaining the diversity of crops is an appropriate adaptation option for food security and livelihood in these communities with a std (1.08038, and a variance of 1.167). Households especially those of small farmers in the study area expressed their readiness to associate other livelihood activities like food crops and livestock rearing (sheep) to increase their income as was observed by Yengoh et al. (2010). This study also shows that the diversification of income sources as a local adaptation option cuts across different sectors (environment, forest, and wildlife, livestock and fisheries, agriculture and rural development, scientific research, finance, and commerce). This finding is supported by Yengoh et al. (2010), that coordination and collaboration are required between sectors to build the needed capacities for improving rural livelihoods and reducing their vulnerability to local climate change. Engaging in non-climate dependent alternative jobs such as driving, masonry works, sale of assorted goods "provision store", shoe repairing, painting, sewing or dressmaking were among the coping measures described by respondents with a std of (0.47279). Although the dominant occupation is farming household members, especially the youths who migrate to urban centres to a search for jobs, results in the rural exodus in the study site. Finally, according to the households, they increase their farm sizes every beginning of the farming season as an adaptation option to local climate variability and uncertainty with a std of (0.21302). During the field survey, the average farm size increased from 1.5 ha in 2000 to 2.5 ha in 2018. As supported by Bele et al. (2013), the increase is a coping and adaptation strategy for these forest dependent communities (Table 8).

Discussions

This study has identified major climate-sensitive livelihood activities in Mambioko forest-dependent communities. These communities solely depend on rain-fed agriculture and forest resources (NTFPs). The levels of dependency on climate-sensitive livelihood (community level ranking) were used based on the significant roles these resources play in sustaining livelihoods. (High dependency = Home consumption and frequent sale of surplus on the local market; Moderate Dependency = Home consumption and occasional sale on the local market; Less dependency = Home consumption only). Agriculture recorded the highest dependency (99.2%). The nature of these activities depends on the availability of assets, resources, labor, skills, education and social capital. Following, local perceptions, their major livelihoods activities have been impacted by past years by climate change associated with indicators such as pests and diseases, low production, erratic rainfall, strong winds, drought and changing seasons. The socioeconomic vulnerability in the study site was estimated using five socioeconomic indicators, which revealed that these communities are highly vulnerable following the findings of Cutter et al. (2008). At an economy-wide level, raising resilience and bolstering coping mechanisms will require the combination of reforms targeted the types of climate change challenges a country may face. Finally, following other studies (IDRC, 2009), households have diversified their crops, sustaining the diversity of crops is an appropriate adaptation option for food security and livelihood in these communities with a std (1.08038, and a variance of 1.167). Households, especially those of small scale farmers, in the study area expressed their readiness to associate other livelihood activities like food crops and livestock rearing (sheep) to increase their income as was observed by Yengoh et al. (2010). This study also shows that the diversification of income sources as a local adaptation option cuts across different sectors (environment, forest and wildlife, livestock and fisheries, agriculture and rural development, scientific research, finance, and commerce). This finding is supported by Yengoh et al. (2010) that coordination and collaboration are required between sectors to build the needed capacities for improving rural livelihoods and reducing their vulnerability to local climate change. Engaging in non-climate dependent alternative jobs such as driving, masonry

works, sale of assorted goods "provision store", shoe repairing, painting, sewing or dressmaking were among the coping measures described by respondents with a std of (0.47279).

Conclusion

This study has investigated the adverse impacts of climate change effects at the household level of forest-dependent communities in the Mambioko CF area in Cameroon's Center region. It has also assessed the different coping and adaptation measures are adopted by these communities in the wake of a changing climate. Socioeconomic vulnerability levels of this ecological zone have also been determined. Generally, the adverse effects of climate change on key livelihoods activities and their impacts on livelihoods over the years are already evident. Community perceptions indicate they are vulnerable to the variation in local climatic conditions and the seasonal calendar, with noted variations in temperature and sunshine, rainfall, and other climate-sensitive schedules such as sowing and harvesting periods.. Regarding future development interventions, key areas to focus on are options for alternative livelihood activities, access to climate information, sustainable agricultural practices, agroforestry practices, and sustainable forest resource management. Significant contributions from civil society groups and relevant governmental institutions can play a key role in minimizing forest-dependent communities' exposure to climate change's impacts. This can be done by creating awareness and helping communities cope and adapt to a changing climate by building on existing coping and adaptation measures while a more scientific approach to ensure sustainable livelihood should be developed.

Recommendations

Based on the literature and results of this study, the following recommendations is considered in enhancing the adaptive capacity of the Mambioko local communities:

a. Community resilience-building plans should be worked out as it will enhance their adaptive capacity thereby reducing their vulnerabilities;
b. The role of national and local governments in further analyzing the vulnerabilities of these communities and their livelihoods resources to ensure intersectoral development of their adaptive capacities;
c. The provision of support to the implementation of national adaptation strategies INGOs and NGOs through community capacity building or projects;
d. Ensuring the implementation of alternatives livelihoods interventions (non-dependent on climate) in these communities should be of prime important;
e. Further research is encouraged in the wake of changing cropping patterns in this area.

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RNT wrote the original draft of the manuscript; ELC and JCT contributed to the explanation and discussions of the results and AFdesigned all figures and tables.

Conflict of interest

The authors declare they have no competing interest in the manuscript.

Data availability

The datasets generated from our surveys are not publicly available to ensure the privacy and confidentiality of the survey participants. However, they are available on reasonable requests from the corresponding author with approval from coauthors if requests do not compromise the confidentiality of survey participants.

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